

What is claimed is:

1. A gas generating composition comprising:
a complex of a metal cation, at least one neutral ligand containing hydrogen and nitrogen, and sufficient oxidizing anion to balance the charge of the metal cation such that when the complex combusts, a mixture of gases containing nitrogen gas and water vapor is produced; and
at least one cool burning organic nitrogen-containing compound.
2. A gas generating composition as defined in claim 1, wherein the complex is selected from the group consisting of metal nitrite ammines, metal nitrate ammines, metal perchlorate ammines, metal nitrite hydrazines, metal nitrate hydrazines, metal perchlorate hydrazines, and mixtures thereof.
3. A gas generating composition as defined in claim 1, wherein the complex is a metal nitrite ammine.
4. A gas generating composition as defined in claim 1, wherein the complex is a metal nitrate ammine.
5. A gas generating composition as defined in claim 1, wherein the complex is a metal perchlorate ammine.
6. A gas generating composition as defined in claim

1 ~~40~~. A method of inflating an air bag comprising combusting a gas generating composition containing a complex of a transition metal cation or alkaline earth metal cation, at least one neutral ligand containing hydrogen and nitrogen, and sufficient oxidizing anion to balance the charge of the metal cation, such that when the gas generating composition combusts, a mixture of gases containing nitrogen gas and water vapor is produced, wherein the composition further contains at least one cool burning organic nitrogen-containing compound.

2 ~~41~~. A method of inflating an air bag as defined in claim ~~40~~, wherein the combustion of the metal complex is initiated by heat.

3 ~~42~~. A method of inflating an air bag as defined in claim ~~40~~, wherein the complex is selected from the group consisting of metal nitrite ammines, metal nitrate ammines, metal perchlorate ammines, metal nitrite hydrazines, metal nitrate hydrazines, metal perchlorate hydrazines, and mixtures thereof.

4 ~~43~~. A method of inflating an air bag as defined in claim ~~40~~, wherein the complex is a metal nitrite ammine.

5 ~~44~~. A method of inflating an air bag as defined in claim ~~40~~, wherein the complex is a metal nitrate ammine.

6 ~~45~~. A method of inflating an air bag as defined in

claim ~~40~~¹, wherein the complex is a metal perchlorate ammine.

~~7~~⁴⁶. A method of inflating an air bag as defined in claim ~~40~~, wherein the complex is a metal nitrite hydrazine.

~~8~~⁴⁷. A method of inflating an air bag as defined in claim ~~40~~, wherein the complex is a metal nitrate hydrazine.

~~9~~⁴⁸. A method of inflating an air bag as defined in claim ~~40~~, wherein the complex is a metal perchlorate hydrazine.

~~10~~⁴⁹. A method of inflating an air bag as defined in claim ~~40~~, wherein the transition metal cation is cobalt.

~~11~~⁵⁰. A method of inflating an air bag as defined in claim ~~40~~, wherein the transition metal cation or alkaline earth metal cation is selected from the group consisting of magnesium, manganese, nickel, titanium, copper, chromium, and zinc.

~~12~~⁵¹. A method of inflating an air bag as defined in claim ~~40~~, wherein the transition metal cation is selected from the group consisting of rhodium, iridium, ruthenium, palladium, and platinum.

~~13~~⁵². A method of inflating an air bag as defined in claim ~~40~~, wherein the oxidizing anion is coordinated with

the metal cation.

14 ~~53~~. A method of inflating an air bag as defined in claim ~~40~~, wherein the oxidizing anion is selected from the group consisting of nitrate, nitrite, chlorate, perchlorate, peroxide, superoxide, and mixtures thereof.

15 ~~54~~. A method of inflating an air bag as defined in claim ~~40~~, wherein the inorganic oxidizing anion and the inorganic neutral ligand are free of carbon.

16 ~~55~~. A method of inflating an air bag as defined in claim ~~40~~, wherein the complex includes at least one other common ligand, in addition to the neutral ligand.

17 ~~56~~. A method of inflating an air bag as defined in claim ~~40~~, wherein the common ligand is selected from the group consisting of aquo (H_2O), hydroxo (OH), perhydroxo (O_2H), peroxo (O_2), carbonato (CO_3), carbonyl (CO), oxalato (C_2O_4), nitrosyl (NO), cyano (CN), isocyanato (NC), isothiocyanato (NCS), thiocyanato (SCN), amido (NH_2), imido (NH), sulfato (SO_4), chloro (Cl), fluoro (F), phosphato (PO_4), and ethylenediaminetetraacetic acid (EDTA) ligands.

18~~57~~. A method of inflating an air bag as defined in claim 40, wherein the complex includes a common counter ion in addition to the oxidizing anion.

19~~58~~. A method of inflating an air bag as defined in claim 57, wherein the common counter ion is selected from the group consisting of hydroxide (OH^-), chloride (Cl^-), fluoride (F^-), cyanide (CN^-), thiocyanate (SCN^-), carbonate (CO_3^{-2}), sulfate (SO_4^{-2}), phosphate (PO_4^{-3}), oxalate ($\text{C}_2\text{O}_4^{-2}$), borate (BO_4^{-5}), and ammonium (NH_4^+) counter ions.

20~~59~~. A method of inflating an air bag as defined in claim 40, wherein the complex and oxidizing anion combined have a concentration in the gas generating composition from 50% to 80% by weight, wherein the gas generating composition further comprises a binder and a co-oxidizer such that the binder has a concentration in the gas generating composition from 0.5% to 10% by weight and the co-oxidizer has a concentration in the gas generating composition from 5% to 50% by weight.

21~~60~~. A method of inflating an air bag as defined in claim 40, wherein the gas generating composition which is combusted further comprising a co-oxidizer.

22~~61~~. A method of inflating an air bag as defined in claim 60, wherein the co-oxidizer is selected from alkali, alkaline earth, or ammonium perchlorates, chlorates, peroxides, and nitrates.

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62. 21 A method of inflating an air bag as defined in claim 60, wherein the co-oxidizer is selected from metal oxides, metal hydroxides, metal peroxides, metal oxide hydrates, metal oxide hydroxides, metal hydrous oxides, basic metal carbonates, basic metal nitrates, and mixtures thereof.

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63. 21 A method of inflating an air bag as defined in claim 60, wherein the co-oxidizer is selected from oxides of copper, cobalt, manganese, tungsten, bismuth, molybdenum, and iron.

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64. 21 A method of inflating an air bag as defined in claim 60, wherein the co-oxidizer is a metal oxide selected from CuO , Co_2O_3 , Co_3O_4 , CoFe_2O_4 , Fe_2O_3 , MoO_3 , Bi_2MoO_6 , and Bi_2O_3 .

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65. 21 A method of inflating an air bag as defined in claim 60, wherein the co-oxidizer is a metal hydroxide selected from $\text{Fe}(\text{OH})_3$, $\text{Co}(\text{OH})_3$, $\text{Co}(\text{OH})_2$, $\text{Ni}(\text{OH})_2$, $\text{Cu}(\text{OH})_2$, and $\text{Zn}(\text{OH})_2$.

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66. 21 A method of inflating an air bag as defined in claim 60, wherein the co-oxidizer is a metal oxide hydrate or metal hydrous oxide selected from $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$, $\text{SnO}_2 \cdot x\text{H}_2\text{O}$, and $\text{MoO}_3 \cdot \text{H}_2\text{O}$.

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67. 21 A method of inflating an air bag as defined in claim 60, wherein the co-oxidizer is a metal oxide hydroxide selected from $\text{CoO}(\text{OH})_2$, $\text{FeO}(\text{OH})_2$, $\text{MnO}(\text{OH})_2$, and $\text{MnO}(\text{OH})_3$.

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74 34 A method of inflating an air bag as defined in claim 73, wherein the binder is selected from nitrocellulose, VAAR, and nylon.

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75 40 A method of inflating an air bag as defined in claim 40, wherein the complex is hexaamminecobalt(III) nitrate, $[(\text{NH}_3)_6\text{Co}](\text{NO}_3)_3$ and the co-oxidizer is copper(II) trihydroxy nitrate $(\text{Cu}_2(\text{OH})_3\text{NO}_3)$.

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76 40 A method of inflating an air bag as defined in claim 40, further comprising carbon powder present from 0.1% to 6% by weight of the gas generating composition, wherein the composition exhibits improved crush strength compared to the composition without carbon powder.

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77 40 A method of inflating an air bag as defined in claim 40, further comprising carbon powder present from 0.3% to 3% by weight of the gas generating composition.

1, wherein the complex is a metal nitrite hydrazine.

7. A gas generating composition as defined in claim 1, wherein the complex is a metal nitrate hydrazine.

8. A gas generating composition as defined in claim 1, wherein the complex is a metal perchlorate hydrazine.

9. A gas generating composition as defined in claim 1, wherein the metal cation is a transition metal, alkaline earth metal, metalloid, or lanthanide metal cation.

10. A gas generating composition as defined in claim 9, wherein the metal cation is selected from the group consisting of magnesium, manganese, nickel, titanium, copper, chromium, zinc, and tin.

11. A gas generating composition as defined in claim 1, wherein the metal cation is a transition metal cation.

12. A gas generating composition as defined in claim 11, wherein the transition metal cation is cobalt.

13. A gas generating composition as defined in claim 11, wherein the transition metal cation is selected from the group consisting of rhodium, iridium, ruthenium, palladium, and platinum.

14. A gas generating composition as defined in claim

1, wherein the oxidizing anion is coordinated with the metal cation.

15. A gas generating composition as defined in claim 1, wherein the oxidizing anion is selected from the group consisting of nitrate, nitrite, chlorate, perchlorate, peroxide, and superoxide.

16. A gas generating composition as defined in claim 1, wherein the inorganic oxidizing anion and the inorganic neutral ligand are free of carbon.

17. A gas generating composition as defined in claim 1, wherein the complex includes at least one other common ligand, in addition to the neutral ligand.

18. A gas generating composition as defined in claim 17, wherein the common ligand is selected from the group consisting of aquo (H_2O), hydroxo (OH), perhydroxo (O_2H), peroxy (O_2), carbonate (CO_3), carbonyl (CO), oxalato (C_2O_4), nitrosyl (NO), cyano (CN), isocyanato (NC), isothiocyanato (NCS), thiocyanato (SCN), amido (NH_2), imido (NH), sulfato (SO_4), chloro (Cl), fluoro (F), phosphato (PO_4), and ethylenediaminetetraacetic acid (EDTA) ligands.

19. A gas generating composition as defined in claim 1, wherein the complex includes a common counter ion in addition to the oxidizing anion.

20. A gas generating composition as defined in claim 19, wherein the common counter ion is selected from the group consisting of hydroxide (OH^-), chloride (Cl^-), fluoride (F^-), cyanide (CN^-), thiocyanate (SCN^-), carbonate (CO_3^{-2}), sulfate (SO_4^{-2}), phosphate (PO_4^{-3}), oxalate ($\text{C}_2\text{O}_4^{-2}$), borate (BO_4^{-5}), and ammonium (NH_4^+) counter ions.

21. A gas generating composition as defined in claim 1, wherein the complex has a concentration in the gas generating composition from 30% to 90% by weight, wherein the gas generating composition further comprises a binder and a co-oxidizer such that the binder has a concentration in the gas generating composition from 0.5% to 12% by weight, and wherein the sum of the amount of co-oxidizer and cool burning compound in the gas generating composition is from 10% to 60% by weight.

22. A gas generating composition as defined in claim 1, further comprising a co-oxidizer other than said cool burning compound.

23. A gas generating composition as defined in claim 22, wherein the co-oxidizer is selected from alkali, alkaline earth, lanthanide, or ammonium perchlorates, chlorates, peroxides, nitrites, and nitrates.

24. A gas generating composition as defined in claim 22, wherein the co-oxidizer is selected from metal oxides, metal hydroxides, metal peroxides, metal oxide hydrates, metal oxide hydroxides, metal hydrous oxides, basic metal carbonates, basic metal nitrates, and mixtures thereof.

25. A gas generating composition as defined in claim 22, wherein the co-oxidizer is selected from oxides of copper, cobalt, manganese, tungsten, bismuth, molybdenum, and iron.

26. A gas generating composition as defined in claim 22, wherein the co-oxidizer is a metal oxide selected from CuO , Co_2O_3 , Co_3O_4 , CoFe_2O_4 , Fe_2O_3 , MoO_3 , Bi_2MoO_6 , and Bi_2O_3 .

27. A gas generating composition as defined in claim 22, wherein the co-oxidizer is a metal hydroxide selected from $\text{Fe}(\text{OH})_3$, $\text{Co}(\text{OH})_3$, $\text{Co}(\text{OH})_2$, $\text{Ni}(\text{OH})_2$, $\text{Cu}(\text{OH})_2$, and $\text{Zn}(\text{OH})_2$.

28. A gas generating composition as defined in claim 22, wherein the co-oxidizer is a metal oxide hydrate or metal hydrous oxide selected from $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$, $\text{SnO}_2 \cdot x\text{H}_2\text{O}$, and $\text{MoO}_3 \cdot \text{H}_2\text{O}$.

29. A gas generating composition as defined in claim 22, wherein the co-oxidizer is a metal oxide hydroxide selected from $\text{CoO}(\text{OH})_2$, $\text{FeO}(\text{OH})_2$, $\text{MnO}(\text{OH})_2$, and $\text{MnO}(\text{OH})_3$.

30. A gas generating composition as defined in claim 22, wherein the co-oxidizer is a basic metal carbonate selected from $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ (malachite), $2\text{Co}(\text{CO}_3) \cdot 3\text{Co}(\text{OH})_2 \cdot \text{H}_2\text{O}$, $\text{Co}_{0.69}\text{Fe}_{0.34}(\text{CO}_3)_{0.2}(\text{OH})_2$, $\text{Na}_3[\text{Co}(\text{CO}_3)_3] \cdot 3\text{H}_2\text{O}$, $\text{Zn}_2(\text{CO}_3)(\text{OH})_2$, $\text{Bi}_2\text{Mg}(\text{CO}_3)_2(\text{OH})_4$, $\text{Fe}(\text{CO}_3)_{0.12}(\text{OH})_{2.76}$, $\text{Cu}_{1.54}\text{Zn}_{0.46}(\text{CO}_3)(\text{OH})_2$, $\text{Co}_{0.49}\text{Cu}_{0.51}(\text{CO}_3)_{0.43}(\text{OH})_{1.1}$, $\text{Ti}_3\text{Bi}_4(\text{CO}_3)_2(\text{OH})_2\text{O}_9(\text{H}_2\text{O})_2$, and $(\text{BiO})_2\text{CO}_3$.

31. A gas generating composition as defined in claim 22, wherein the co-oxidizer is a basic metal nitrate selected from $\text{Cu}_2(\text{OH})_3\text{NO}_3$, $\text{Co}_2(\text{OH})_3\text{NO}_3$, $\text{CuCo}(\text{OH})_3\text{NO}_3$, $\text{Zn}_2(\text{OH})_3\text{NO}_3$, $\text{Mn}(\text{OH})_2\text{NO}_3$, $\text{Fe}_4(\text{OH})_{11}\text{NO}_3 \cdot 2\text{H}_2\text{O}$, $\text{Mo}(\text{NO}_3)_2\text{O}_2$, $\text{BiONO}_3 \cdot \text{H}_2\text{O}$, and $\text{Ce}(\text{OH})(\text{NO}_3)_3 \cdot 3\text{H}_2\text{O}$.

32. A gas generating composition as defined in claim 1, further comprising a binder.

33. A gas generating composition as defined in claim 32, wherein the binder is water soluble.

34. A gas generating composition as defined in claim 33, wherein the binder is selected from naturally occurring gums, polyacrylic acids, and polyacrylamides.

35. A gas generating composition as defined in claim 32, wherein the binder is not water soluble.

36. A gas generating composition as defined in claim

35, wherein the binder is selected from nitrocellulose, VAAR, and nylon.

37. A gas generating composition as defined in claim 1, wherein the complex is hexaamminecobalt(III) nitrate, $[(\text{NH}_3)_6\text{Co}](\text{NO}_3)_3$ and the co-oxidizer is copper(II) trihydroxy nitrate $(\text{Cu}_2(\text{OH})_3\text{NO}_3)$.

38. A gas generating composition as defined in claim 1, further comprising carbon powder present from 0.1% to 6% by weight of the gas generating composition, wherein the composition exhibits improved crush strength compared to the composition without carbon powder.

39. A gas generating composition as defined in claim 1, further comprising carbon powder present from 0.3% to 3% by weight of the gas generating composition.

a gas generating composition comprising:

- a complex of a transition metal cation or alkaline earth metal cation and a neutral ligand containing hydrogen and nitrogen, such that when the complex combusts, a mixture of gases containing nitrogen gas and water vapor is produced;
- sufficient oxidizing anion to balance the charge of the metal cation; and
- at least one cool burning organic nitrogen-containing compound; and
- an ignitor for initiating the combustion of the composition.

a complex of a transition metal cation or alkaline earth metal cation and a neutral ligand containing hydrogen and nitrogen, such that when the complex combusts, a mixture of gases containing nitrogen gas and water vapor is produced;

at least one cool burning organic nitrogen-containing compound; and

an ignitor for initiating the combustion of the composition.

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79. A gas generating device as defined in claim 78, wherein the ignitor for initiating the combustion includes an igniter composition comprising a mixture of different igniter compositions.

80. A gas generating device as defined in claim 78, wherein the ignitor for initiating the combustion includes an igniter composition comprising a mixture of Mg/Sr(NO₃)₂/nylon and B/KNO₃.

81. An automobile air bag system comprising:
a collapsed, inflatable air bag;
a gas-generating device connected to the air bag for inflating the air bag, the gas-generating device containing a gas-generating composition comprising:
a complex of a transition metal cation or alkaline earth metal cation and a neutral ligand containing hydrogen and nitrogen, such that when the complex combusts, a mixture of gases containing nitrogen gas and water vapor is produced;
sufficient oxidizing anion to balance the charge of the metal cation; and
and at least one cool burning organic nitrogen-containing compound; and
an ignitor to ignite the gas-generating composition.

82. A vehicle containing a supplemental restraint system having an air bag system comprising:

a collapsed, inflatable air bag;

a gas-generating device connected to the air bag for inflating the air bag, the gas-generating device containing a gas-generating composition comprising:

a complex of a transition metal cation or alkaline earth metal cation and a neutral ligand containing hydrogen and nitrogen, such that when the complex combusts, a mixture of gases containing nitrogen gas and water vapor is produced;

sufficient oxidizing anion to balance the charge of the metal cation; and

at least one cool burning organic nitrogen-containing compound; and

an ignitor for igniting the gas-generating composition.

83. A gas generating composition as defined in claim 1, wherein said cool burning compound has a heat of formation of less than about -400 cal/g.

84. A gas generating composition as defined in claim 1, wherein said cool burning compound has a heat of formation of less than about -600 cal/g.

85. A gas generating composition as defined in claim 1, wherein said cool burning compound is a guanidine salt or a guanidine derivative.

86. A gas generating composition as defined in claim 1, wherein said cool burning compound is guanidine nitrate.

87. A gas generating composition as defined in claim 1, wherein the amount of said cool burning compound is greater than about 0 wt.% and up to about 40 wt.%.

88. A gas generating composition comprising:
a complex of a metal cation and a neutral organic, aliphatic ligand containing hydrogen and nitrogen such that when the complex combusts, a mixture of gases containing nitrogen gas and water vapor is produced; and
an amount of oxidizing anion which is sufficient to at least partially balance the charge of the metal cation.